# The danger of free-roaming dogs in peri urban settings: Two rabid dogs on rampage that bit 29 humans and 18 domestic animals in Wakiso and Luweero districts, Central Uganda

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## Abstract

# Background

Uganda averages 14,000 dog bites annually, with 86% caused by free-roaming dogs. Unfortunately, there is limited documentation to inform interventions. Here, we documented circumstances of attacks from free-roaming dogs on rampage in Central Uganda to identify critical gaps in the detection, preparedness, and response of the community.

# Methods

We conducted an exploratory case study to actively survey attacks from rampaging dogs in Kampala Metropolitan Area, Central Uganda between November 2022 - November 2023. We traced the dogs responsible to immobilise and rule out rabies. We interviewed the victims and community to determine the circumstances of the bites, the healthcare sought and sentiments towards free-roaming dogs. We followed-up after 40 days, to assess adherence to rabies post exposure prophylaxis and to document any challenges encountered.

# Results

Of the 8 cases reported, only two cases that occurred in Matugga and Mawale parishes fulfilled our criteria for rampage while the rest were predation, an incidental bite and straying into someone's residence. The two rampaging dogs' bit 29 humans, mostly children (75.8%) and 18 domestic animals. Immobilisation in Matugga failed while the dog in Mawale was killed by the community in a mob. Due to limited knowledge, 93.1% of the victims did not wash the wound and go the medical facility as recommended by WHO. Instead, they sought healthcare from the traditional healer (58.6%), stayed home or applied herbs (20.7%). Parallel with our advice, those victims sought medical care however they encountered challenges not limited to lack of funds and poor services at public health facilities. After inflicting bites, the dogs responsible and other free-roaming dogs were killed by hitting them with sticks in a mob.

# Conclusions

Overall, our findings demonstrate the impact that a lone free-roaming dog with rabies can have on a community. They also reveal how poverty, limited awareness, reliance on traditional healers, and barriers to medical care access impede health care received by dog bite victims in this setting. Implementing educational campaigns and responsible ownership of free-roaming dogs should help reduce dog bites and rabies in Central Uganda, as well as in other socioeconomically similar settings.

# INTRODUCTION

There are between 700 million to one billion dogs globally, of which 75% roam freely (1–6) Such dogs frequently inhabit densely populated urban centers (i.e., “slums”) because of factors such as poor garbage management (7), abandoned buildings (8), and unrestrictive dog ownership practices (9). Several studies in Uganda have documented the status of free-roaming dogs. For example, Hyeroba et al. (2017) described village dogs (“free-roaming dogs”) in rural Western Uganda as “nasty” animals that lived a short life because of infectious diseases and attacks from wildlife. While Warembourg et al. (2021) found that free-roaming dogs in Soroti district, Eastern Uganda covered between 1.3-19.1hectares (ha) in search for food and mates.

Where dogs roam freely and exist in high densities, they may conflict with people (10), livestock, and wildlife (11, 12), often with negative consequences (11, 13). They may attack, injure, or kill people and livestock, causing distress to the communities they inhabit (1, 14, 15). Globally, over 10 million dog bites are recorded annually (16). Majority of those dog bites are reported in low and middle income countries at a range of 1.03–25.7 bites per 1,000 people annually (16).

Uganda is among the top ten African countries with the highest number of reported dog bites (17). Surveillance data from medical facilities in Uganda from 2001–2015 reported 196,000 dog bites to humans (18). It is worth noting that free-roaming dogs were responsible for 86% of the bites registered at medical facilities in Central Uganda between April-October 2019 (10), and 20% of those bites resulted into confirmed rabies cases (14).

Information on dog bites in Uganda is collected passively from medical facilities using the District Health Information System 2 (DHIS2) (18) and paper based monthly reports compiled by the District Veterinary Officers (DVO) (14, 19). While the passively collected data captures the incidence of dog bites, substantial information on the behaviour of the dog and victims, other humans and/or animals bitten by the same dog, and the cause of aggression is lost (20). Moreso, the victims who may use alternative remedies such as local herbs or obtain treatment from traditional healers are never documented (10). To overcome this, Fevre et al. 2005 proposed an active surveillance approach focused on small-scale active case detection as a valuable tool for collection of precise information on dog bites and rabies cases in Uganda (21).

In the current study, we tracked active cases of bites from free-roaming dogs on rampage in Kampala Metropolitan Area (KMA), Central Uganda, to document the circumstances of the dog bites including the behaviour of the dog(s), reaction of the victims and community to the rampage, and sentiments towards free-roaming dogs. We further documented the health seeking behaviours, compliance of the victims to the WHO guidelines for preclinical management of dog bite wounds, access and adherence to rabies post exposure prophylaxis, beliefs regarding free-roaming dogs and rabies risk.

# METHODS

## Study sites

This study was carried out in Kampala Metropolitan Area (KMA), Central Uganda which encompasses the capital city and neighbouring districts. The KMA area is highly congested and houses several slums (7), which provides a niche for free-roaming dogs to thrive (8). Based on the human: dog ratio of 25:1 estimated previously (22), the KMA has the highest population of free-roaming dogs in Uganda. Consequently, dog bites are predominant in this area (10).

# Study design

An exploratory case study was used to document the circumstances involving rampaging free-roaming dogs. We considered rampage because it is one of the cardinal signs of rabies infection (“mad dog disease”). We defined rampage as an incident where a single dog caused successive attacks to people and/or domestic animals within the same locality. An attack to a single human or livestock was defined as an incidental bite whereas that involving a pack was defined as predation. We used a case-based active surveillance because it has been used elsewhere to provide detailed and accurate account of the circumstances surrounding dog bites (21, 23).

# Data collection

The District Veterinary Office (DVO), veterinary officers (VO) and local leaders were contacted and requested to report incidents involving free-roaming dogs on rampage in their community. We chose to obtain information from the DVO because victims in Uganda report bite incidents to the VO or the DVO to get assessment of rabies risk, before proceeding to the medical facility (19, 24). Local leaders are often notified as well. For the cases reported, we responded with a multipronged approach: (1), identifying all the victims, (2), determining the extent of the injury and the health care received, (3), locating and immobilising the dogs on rampage to rule out rabies, and (4), obtaining sentiments of the affected community on free-roaming dogs.

### In-depth interviews

In-depth interviews were performed as described previously (10). Briefly, interviews were administered to the victims and purposively selected key informants including 5 community members, 2 local leaders, 2 medical officers, and 3 veterinary officers. The interviews were recorded using a digital audio recorder (SONY ICD-PX470 Stereo IC Voice Recorder, Tokyo Japan). Additional interviews of the victims were recorded 40 days later to document adherence with the rabies PEP regimen, the costs and challenges encountered in the process. To maintain consistency, guiding questions were composed and used during the interviews (Additional file 1). Saturation was considered when no new information was provided.

### Immobilising the rampaging dogs

We worked with the VO and local leaders to locate the rampaging dogs with the intention of immobilisation to prevent further attacks and establishing the cause of the aggression. The team was equipped with dog catchers, trap nets, cages, and dog leashes for physical restraint, and xylazine (Xyla®, 20mg/ml, Interchemie Werken "De Adelaar" B.V., Castenray, Netherlands), ketamine hydrochloride

(Ketamax®, 50 mg/ml, Troikaa Pharmaceuticals Ltd, Satya Marg, India) and thiopental sodium (thiopental 500mg, Panpharma UK Ltd, Southport, United Kingdom) for chemical immobilisation. Any immobilised dog was confined individually at the small animal holding facility at the College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB), Makerere University. Immobilised dogs that presented with signs consistent with rabies infection were monitored for 10 days and euthanised if symptoms progressed (25). Euthanasia was achieved first by sedation with xylazine (0.15 mg/kg bodyweight intramuscular using a jab stick) followed by a bolus of thiopental sodium (50 mg/kg intravenous) (26, 27). If the dog was already dead by the time of the field visit, the team recovered the carcass, placed it in tightly sealed biohazard bags and carried it in a cool box for necropsy at Central Diagnostic Laboratory (CDL) at COVAB, Makerere University .

### Confirmatory diagnosis for rabies

We conducted whole brain extraction and histopathology at CDL. Fluorescent Antibody Test (FAT) for rabies diagnosis was performed at the National Animal Disease Diagnostics and Epidemiology Centre (NADDEC) part of the Ministry of Agriculture, Animals Industry and Fisheries (MAAIF) in Entebbe (28). The FAT was performed with minor modifications as described previously (29). Briefly, a thin impression smear was made on a glass slide, flooded with 100% cold acetone (recovered from – $20^0$C) and left to stand for 30 minutes. A drop of conjugate was added to the slide and incubated in a moisturised chamber at $37^0$C for 30 minutes. The slide was washed with Phosphate Buffered Saline (PBS) and a drop of 20% glycerol was added followed by a cover slip. The slide was viewed under a fluorescence microscope. We used reference positive and negative controls archived at NADDEC. A positive test was considered by the presence of apple green, fluorescent particles in the brain sample.

# Data management and analysis

The dog bites were categorised into three forms of exposure to rabies, according to the World Health Organisation (WHO) guide (16). According to this classification, category I involves contact between saliva and intact skin, category II involves minor scratches or abrasions of the skin without bleeding, and category III involves single or multiple transdermal wounds accompanied by bleeding (30).

The healthcare pursued was compared to the WHO preclinical guidelines on the management of dog bite wounds for suspected rabies exposure. The WHO recommends washing the fresh wound with running water and disinfectant/soap for 15 minutes and then rushing to a medical facility for rabies post exposure prophylaxis (PEP) within 24 hours (31, 32). A victim was considered compliant if they performed the two steps in correct order and non-compliant if they did not take any of the steps or missed one of the steps.

The recordings of the interviews were transcribed into written text manually. The transcripts were reviewed by an independent person to verify the accuracy of the transcription. NVivo 11.4.1® software

was used deductively to code the transcripts and to generate key themes. This information from the themes was used to form explanatory points.

# RESULTS

## Number and nature of the cases reported

We received 8 reports of attacks from free-roaming dogs in Wakiso (6), Luweero (1) and Kampala (1) between November 2022-November 2023 (Additional file 2). From the 8 reports, the two cases from Matugga and Mawale parishes in Wakiso and Luweero districts respectively were consistent with our case definition of rampaging dogs. The other cases involved a single bite incident to a human, predation to livestock (2 cases), abnormal behaviour (biting foreign objects) (2 cases) and one incident of a dog that strayed in someone's residence. The dogs involved were only traceable in 4/8 incidents. For those traceable, 2 were killed by the community in a mob, 1 was euthanised by the VO and 1 was shot dead by a Police officer. The dogs killed by the community and the one euthanised by the VO were confirmed for rabies, whereas the dog that was shot dead after it strayed into someone's residence was negative.

## Characteristics of the attacks in Matugga and Mawale

The dog attacks in Matugga were scattered across three villages namely Kiryagonja, Lwadda-A and Lwadda-B while in Mawale the cases were clustered in Mawale trading center (Fig. 1).

Figure 1. The location of the dog bites in Matugga and Mawale parishes

## The demographics and behaviour of the rampaging dogs

The community members in Matugga described the rampage dog as local breed (mongrel), brown, and small while that of Mawale was local breed, brown, male, and medium sized. The ownership of the rampaging dogs was undetermined because the community members who were claimed to be the owners of those dogs denied the allegations. According to reports from the dog bite victims, the rampaging dogs ran restlessly and attacked without being provoked.

*"I was walking to my home; the dog ran from the bush and bit me. I fought it, and it ran away. Shortly, it attacked and bit another lady who was nearby. That lady was carrying her child. She fell to the ground and dropped the child, then the dog also bit the child".* (DBV, Matugga)

## Immobilising the rampaging dogs

Our team, VO and community members for 3 days attempted to locate the dog responsible for bites in Matugga but failed. It was presumed that the rampaging dog may have died in hiding because no more attacks were reported after 3 days. During the follow-up visit, a community member reported what may have happened to that dog.

*“Our bull encountered the dog in the early morning of January 8th, 2023, at approximately 3:00–4:00 am. We did not come out of the house due to fear. At daybreak, the bull had several injuries but no sight of the dog. A few days later, we investigated a foul smell in the nearby bush to find a small brown local dog with multiple bruises and injuries all over its body. We disposed it under Ejirikiti tree*”. (CM, Matugga)

When queried why she did not report the incident, she replied:

“*Traditionally in Buganda, a dead dog is disposed under Ejirikiti tree*.”

By contrast, the dog in Mawale was killed by a mob on the first day of the attacks and dumped in the bush. Our team retrieved the carcass within 12 hours after death and submitted it to CDL for rabies diagnosis.

# Laboratory diagnosis for rabies

Histopathological examination of the brain lesions revealed moderate to marked foci of perivascular cuffing by mononuclear inflammatory cells with severe non-suppurative encephalitis, suggesting virus-induced encephalitis. Presence of apple green, fluorescent particles after performing FAT confirmed the presence of rabies in the brain samples (Fig. 2).

Figure 2. Micrographs of histopathology and fluorescent antibody test for rabies diagnosis

# The dog bite victims

Altogether 47 bite incidents were recorded: 37 in Matugga and 10 in Mawale. Of those, 29 were inflicted to humans including 22 (75.9%) children aged 1–11 years, 6 ( 20.7%) women aged 32–49 years and a 72-year-old man (3.4% ) (Table 1). Bites were inflicted on 18 domestic animals that included 6 goats, 2 cattle, 2 pigs, one sheep, a duck and 6 owned free-roaming dogs (Fig. 3). Twelve domestic animals (66.7%, 12/18) including 6 owned free-roaming dogs, a bull, and 5 goats were vaccinated by the VO on a private arrangement. By the time of the follow-up, one bull and goat had been sold for slaughter, one sheep culled and buried, and one pig had died. Unfortunately, no diagnosis was made for the domestic animals that died because the owners did not report those incidents.

Figure 3. Images of bite wounds inflicted on humans and domestic animals

# Category of the bites sustained by the victims

Most of the victims (27/29; 93.1%) sustained category III injuries to various parts of the body (Table 1). The bites were single (26/29; 89.7%) and multiple (3/29; 10.3%) wounds, sustained on the arms (14/29; 48.3%), leg (6/29; 20.7%), trunk (8/29; 27.6%) and head (3/29; 10.3%).

Table 1
The dog-bite victims, category of exposure and health care

| ID | Age group, sex | Category of rabies exposure[a], anatomical site | Healthcare interventions sought by the victims | |
|---|---|---|---|---|
| | | | Primary | Secondary |
| 1 | Child, male | III, hand | Trad. healer | - |
| 2 | Adult, female | II, back | Wound cleaning-stayed home | - |
| 3 | Child, female | III, thigh | Trad. healer | Priv. MF |
| 4 | Adult, female (mother to #3) | III, arm | Trad. healer | - |
| 5 | Child, male | III, hand | Trad. Healer | - |
| 6 | Child, female | III, arm | Wound cleaning- Trad. healer | - |
| 7 | Child, female | III, shoulder | Wrapped the wound with cloth- Priv. MF | - |
| 8 | Child, male | III, back | Trad. healer | - |
| 9 | Male | III, foot | Trad. healer | - |
| 10 | Child, female | III, hand | Herbs | - |
| 11 | Child, female | III, shoulder | Herbs | - |
| 12 | Child, female | III, hand | Pub. MF | - |
| 13 | Child, female | III, head | Trad. healer | Priv. MF |
| 14 | Child, female | III, shoulder | Herbs | - |
| 15 | Adult, female (mother to #16) | III, thigh and hand | Pub. MF | - |
| 16 | Child, female | III, head | Pub. MF | - |
| 17 | Child, male | III, knee | Trad. healer | - |
| 18 | Child, male | III, both hands | Trad. healer | Pub. MF |
| 19 | Child, male | III, arm | Trad. healer | Pub. MF |
| 20 | Child, male | III, hand | Trad. healer | |

Pub. MF: Public Medical Facility, Priv. MF: Private Medical Facility, Trad. healer: Traditional healer,
[a]Category of rabies exposure: Category I involved contact between saliva and intact skin, category II involved minor scratches or abrasions of the skin without bleeding, and category III involved single or multiple transdermal bites accompanied by bleeding

| ID | Age group, sex | Category of rabies exposure[a], anatomical site | Healthcare interventions sought by the victims | |
|---|---|---|---|---|
| | | | Primary | Secondary |
| 21 | Child, female | III, shoulder | Trad. healer | Pub. MF |
| 22 | Adult, female | III, thigh | Pub. MF | - |
| 23 | Child, female | III, shoulder | Trad. healer | - |
| 24 | Adult, female | III, hands and thigh | Trad. healer | Pub. MF |
| 25 | Child, male | III, arm | Herbs | - |
| 26 | Adult, female | III, trunk | Priv. MF | - |
| 27 | Child, male | III, arm | Trad. healer | Pub. MF |
| 28 | Child, female | II, trunk | Trad. healer | - |
| 29 | Child, female | III, head | Pub. MF | - |

Pub. MF: Public Medical Facility, Priv. MF: Private Medical Facility, Trad. healer: Traditional healer, [a]Category of rabies exposure: Category I involved contact between saliva and intact skin, category II involved minor scratches or abrasions of the skin without bleeding, and category III involved single or multiple transdermal bites accompanied by bleeding

# Circumstances of dog bites

At the time of the attack, 72.4% (21/29) of the victims were either playing (children) or doing household chores at home 10.3% (3/29). While two women, a child, and the elderly man were walking on the street (Additional file 3). In one scenario, a mother sustained a bite because she confronted the dog to rescue her child.

# Compliance with WHO guidelines for preclinical management of animal bites

For the first step, 93.1% (27/29) of the victims did not wash the wound after sustaining the dog bite. For the second step, 75.9% (22/29) did not go to the medical facility. They opted for the traditional healer 58.6% (17/29), self-medicated 13.7% (4/29) and one person who stayed at home. On their own, seven individuals 41% (7/17) that had received treatment from the traditional healer reported to the medical facility for a second opinion. The reasons for change of decision were mistrust in the procedure performed by the traditional healer.

"*My wife had taken my child to the traditional healer, When I arrived, I asked what treatment my child had received. I was informed that the traditional healer had placed a black stone on the leg to treat the dog*

*bite. I was furious, and I asked the traditional healer to refund my money so that I could go to the medical facility".* (DBV, Matugga)

# Access to rabies post exposure prophylaxis

Four victims (13.7%, 4/29) accessed the first shot of rabies PEP within 12 hours from private medical facilities. The majority (62.1%, 18/29) received rabies PEP between 12–24 hours whereas 4 victims (13.7%) received the first shot after 48 hours. For the victims who delayed receiving rabies PEP, three (75%, 3/4) had gone to the traditional healer while the other stayed home.

Primarily, 13 victims (44.8%) accessed the first shot of rabies PEP from private medical facilities. However, 8 of them (61.5%) transferred to public medical facilities to receive the rest of the doses. They changed after receiving information that the same treatment was free at public medical facilities. On the other hand, 16 victims (55.2%) received the rabies shots from public medical facilities. In subsequent visits, that number increased to 24 (82.8%) after the 8 victims who had initially gone to the private medical facilities moved to public medical facilities in search of the free rabies PEP.

# The cost of rabies post exposure prophylaxis

Rabies PEP was freely available at public medical facilities most of the time (55/103; 53.4%). However, on 48/103 accounts (46.6%), the victims paid an extortion to the attending medical officers before receiving the treatment or were asked to purchase the rabies PEP from privately owned pharmacies near those medical facilities. On average, those victims paid 3–5 USD to access rabies PEP compared to their counterparts who paid 13–15 USD for the similar treatment at private medical facilities.

"*I was informed that the free medicine provided by the government was finished, but the attending medical officer said I could pay some money to receive rabies PEP from his own reserve*". (DBV, Matugga)

For those who could not afford, the medical officers at one of the public medical facilities advised them to pair up so that they could buy 1 dose that was shared.

*"The doctor asked me to buy the medicine (sic) from a pharmacy. I could not afford, so he asked me to find another person to pair with. We collected the money and bought 1 dose which was divided among the two of us".* (DBV, Matugga)

# Adherence to rabies post exposure prophylaxis regimen

Two victims (6.9%) received a 3 dose prescription while 27 victims (93.1%) received a 5 dose prescription at private or public medical facilities. Overall, 93.1% (27/29) of the victims completed the rabies PEP regimen. Two victims (6.9%), a minor and a woman from Matugga did not complete their prescription. Interestingly, the woman mentioned above, who was also taking her child for the same treatment stopped after the second shot but continued to take her child to complete 5 shots. When asked about this, she replied.

"*For me, my wounds had healed, and I did not have a reason to continue with the treatment. However, I continued to take my child because I cannot take a chance with my child's life, but for me, it is ok even if I stop".* (DBV, Matugga)

# Challenges encountered by the victims in the process of acquiring rabies PEP

We encouraged the victims (75.9%, 22/29) who had not sought medical care to do so because the dogs responsible for the bites had shown clinical signs consistent with rabies infection (33). Most individuals were amenable to the advice offered, but the following challenges were encountered.

# 1. Lack of money for transportation to the medical facility

Six victims (27.3%) reported that they were unable to afford the cost of transportation to the medical facility. We worked with local leaders to organise subsidised transportation to a public medical facility so that the victims could access the free rabies PEP.

# 2. Hesitancy among the victims in seeking medical assistance from public medical facilities

We encouraged those victims to utilise the free rabies PEP at public medical facilities, but some of the individuals were hesitant to the suggestion.

*"I don't want to go to public medical facilities; you reach there (sic) but those doctors pay no attention to you. They only give attention (sic) if you pay money or if you know someone influential that can call and talk to them".* (DBV, Matugga)

# 3. Victims that received "treatment" from the traditional healer were hesitant to seek for secondary treatment at medical facilities

The victims complained that they had already spent 40–65 USD to obtain "treatment" from the traditional healer and did not have money to pay for medical care.

"*I was advised by other community members and fellow victims to get treatment from the traditional healer in Kagoma. The 'doctor' has been treating people bitten by snakes and dogs for over 20 years".* (DBV, Mawale)

# 4. Sometimes the victims missed receiving their shots because the medical officers were not available

Three individuals (10.3%, 3/29) reported that they missed receiving their shot on the day they went to the public medical facility because they arrived past 5:00 pm. They were informed that the medical officers responsible for administering rabies PEP were available only during working hours (9:00 am-5:00pm).

# Community reactions towards the rampaging dogs

After registering several bites, the local leaders in Matugga on day 1 mobilised men in the community to kill the dog responsible, but they failed to locate it. Subsequently, some community members autonomously conducted an elimination campaign of free-roaming dogs, hitting them with sticks and stones in a mob. Carcasses were presented to the victims for identification. However, none of the dog presented matched the description given by the victims. Similarly, the community leaders in Mawale mobilised men to chase and kill the rampaging dog. They successfully killed the dog on the first day of the attacks and dumped it in the bush. According to the local leader, three other dogs that had instigated similar attacks in this area were killed and disposed in the same manner.

# Community sentiments towards free-roaming dogs

The victims wanted the free-roaming dogs removed from the community by any means possible.

*"Some members of our community keep up to 10 dogs which they let to roam; such dogs should be poisoned".* (DBV, Matugga)

However, some members of the community wanted only the un-owned free-roaming dogs ("feral") poisoned but not the owned free-roaming dogs.

"*I want all those wild free-roaming dogs poisoned; however, if they do so, my dog may be killed, since it is a free-roaming dog. It is better for the authorities to inform the community to chain their dogs before applying the poison*". (CM, Matugga)

# Previous interventions for control of free-roaming dogs

According to the local leader in Matugga, the Wakiso district veterinary office conducted mass poisoning of free-roaming dogs in 2020. By the time of the incident (January 6th, 2023), the leaders had submitted another request for mass poisoning following complaints from the community. In Mawale, no attempt had been implemented to control the free-roaming dogs besides a mass rabies vaccination campaign.

# Reported ownership of dogs in Matugga and Mawale

The community members reported four categories of dogs:

**1. Confined owned dogs**: The interviewed members reported that well-off people ("rich") kept exotic dogs that were expensive to acquire and were always confined in a perimeter fence around their homes.

"*The rich people keep their dogs in the fences, and they care for them. I have never seen an exotic dog roaming. However, the local dogs that belong to poor people who do not care for them are the ones that*

*roam and bite us".* (DBV, Matugga)

**2. Owned free-roaming dogs**: These were free-roaming dogs that were owned by a community member or were observed frequently resident at a person's home. For the latter, the community members attributed presence of those dogs in homes to ownership. However, complainants stressed that such owners often denied ownership of those dogs after they attacked people or livestock.
"*My goat was attacked and killed by a free-roaming dog, but when I contacted the owner, they denied ownership*". (CM, Mawale)

**3. Un-owned free-roaming dogs ("feral")**: The community members reported several dogs that were not owned by any community member. An example was given for a pack of 5–10 dogs that were resident at a nearby cemetery.

**4. Community owned free-roaming dogs**: Some dogs were identified as "community dogs". Those were free-roaming dogs known and cared for by the community, but no one claimed absolute ownership.
"*That dog ("Danger") has been living in Kiryagonja town for many years. We do not know where it came from, but the people in the town love it and give it food because it is a very peaceful dog".* (CM, Matugga)

# DISCUSSION

To the best of our knowledge, the incident in Matugga records the highest number of successive bites inflicted by a single-rabid dog in Uganda and elsewhere in the world, and the situation in Mawale could have been similar if the rampaging dog had not been killed by the community. Those incidents are like the 1942 Los Angeles case, where twenty domestic dogs and one cat sustained bites from a single rabid dog (34). However, our case is unique in that the rabid dogs attacked both humans and domestic animals from the same community. The rampaging dog in Matugga was untraceable because of the congested settlements ("slum"), which also made it easy to encounter people (35). A study by Reece et al. (2021) confirmed that availability of congested settlements was a predictor for occurrence of dog bites. Since modifications to infrastructure is costly and complex, we propose that emphasis could be placed on sensitising the community on the dangers of free-roaming dogs ("rampage, predation and nuisance") in such settlements in Central Uganda and other similar settings (36, 37).

Most of the victims in our study were children and women, consistent with prior studies from Kenya, Nigeria, and the United Kingdom (38–41). Literature shows that children are more exposed to dog bites because they attempt to play with the dogs or approach them too closely (10). In contrast, the children in this report did not play with or provoke the rampaging dogs, consistent with findings by a study in Trinidad and Tobago (41). Here, there was only one incident where the mother was bitten because she attempted to defend her child from the rampaging dog. This finding stresses the complexity involved in dealing with rabid free-roaming dogs because the disease-induced aggression results into unprovoked and unpredictable attacks.

A wide range of domestic animals including cattle, goats, sheep, pigs, poultry, and owned free-roaming dogs were attacked by the rampaging free-roaming dogs. After sustaining bites, most of those animals were vaccinated against rabies by the area veterinarian on a private arrangement. Thus, the people that could not afford veterinary services were not assisted. This is a major surveillance and veterinary service delivery gap because such animals could play an integral role in sustaining rabies endemicity (42). According to the Centers for Disease Control and Prevention (CDC), such animals should be either euthanised or vaccinated and quarantined for 6 months while being monitored by a veterinarian (43). However, this may not be feasible in our settings because of privatised veterinary services and limited infrastructure for quarantine (44). Besides that, data of animal bites is often overshadowed by the focus on human bites. For example, published data sourced from the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) reports mainly human bites (14) and the newly adopted National Rabies Elimination Strategy for Uganda 2022–2030 does not mention tracing and quarantine of animals bitten by rabid dogs. If the target to end rabies by 2030 is to be achieved, MAAIF and other stakeholders through the one health approach need to prescribe protocols for handling animals that have been bitten by rabid dogs.

We note with concern that a small but substantial number of livestock that sustained bites from the rabid dogs were slaughtered for human consumption. The practice of eating carcases of diseased animals is widely reported in Uganda and has resulted in outbreaks of zoonotic diseases. For instance, the anthrax outbreak in Kween district, Eastern Uganda in 2018 was due to consumption of dead cattle (45). Elsewhere, two people in Vietnam in 2009 died after consuming a rabid dog and cat (25). Therefore, the consumption of livestock bitten by suspected rabid dogs in Central Uganda raises concerns of public health risk.

The communities in Central Uganda practiced indiscriminate killing of free-roaming dogs by methods like poisoning, hitting with sticks or shot with bullets. It was shocking to discover that killing nuisance dogs with sticks in a mob was a routine in Mawale, highlighting the fragile coexistence between humans and free-roaming dogs. Literature shows that humans often resort to lethal measures where dogs have injured or killed livestock, children, and when they were perceived to be ownerless (46). In coherence, the victims in this study supported the elimination of the free-roaming dogs by any means possible. Unfortunately, such measures are unsustainable, unethical (47, 48) and may worsen the dog bites incidents (49, 50). Hence, further studies are needed to propose alternative intervention measures to dissolve the existing tension between the humans and free-roaming dogs in Central Uganda.

While coming up with alternative measures, one must consider how the diverse categories of free-roaming dogs reported (owned, un-owned and community dogs) and sentiments towards them might interfere with the success of those interventions. For instance, the proposal by the victims to eliminate all free-roaming dogs was opposed by the owners of the free-roaming dogs. Instead, they proposed that they could temporarily restrain the owned free-roaming dogs to allow poisoning the un-owned free-roaming dogs (“feral”). Considering that most of the free-roaming dogs might be owned (11, 22, 51), such an approach would not work. Furthermore, the perception of the community that free-roaming dogs are local

breed dogs owned by poor individuals highlights potential interlinkages between poverty, breed preferences and dog ownership (22, 52). Moving forward, comprehensive studies of the population dynamics of free roaming dogs, community sentiments towards free-roaming dogs and factors that influence dog ownership are needed for realistic recommendations.

The carcasses were dumped under the tree shade of *Erythrina abyssinica* (locally known as Ejilikiti tree), according to traditional practices. This finding highlights how carcasses handling and disposal practices by the grass root communities in Central Uganda undermine disease surveillance while predisposing other domestic animals, wildlife, and humans to rabies. Changing such traditional practices may take time, especially in local communities where people believe that burying animal carcasses casts a bad omen to society and results into human deaths (53). This calls for strengthening educational campaigns and providing alternative procedures for disposal of animal carcases in Central Uganda.

We documented deficiencies in the management of dog bites and compliance to WHO guidelines among 93.1% of the victims. For example, most of the victims visited the traditional healer to receive the black stone treatment (Additional file 4). Unfortunately, the efficacy of the black stone against rabies is unproven(10, 54) and there have been reports of death among victims that received this treatment (10). This finding highlights how lack of awareness among community members contributes to poor healthcare seeking behaviour among the victims (54–56). For example, some of the victims were not aware of free rabies PEP services at the public medical facilities. The Ministry of Health should increase education campaigns to address the glaring knowledge gaps. It is worth noting that some of the victims who had received the black stone treatment identified flaws in that remedy and on their own sought secondary opinion from medical facilities, while the rest heeded to our advice. This shows that if implemented, education campaigns would yield substantial results in this setting.

We note that individuals referred to public medical facilities for rabies PEP were hesitant to accept due to perceptions of poor service, especially for persons without money or social influence. Our findings showed that some medical officers at public medical facilities extorted money from the victims before administering rabies PEP, which discouraged the patients seeking medical treatment. These finding are consistent with previous reports of deficiencies in Uganda's public medical care system (57, 58). Whereas the government has made efforts to make rabies PEP accessible at Health centre IV, regional- and National-referral hospitals, challenges like limited stocking of rabies PEP (20), corruption tendencies (57), rabies PEP services limited to working hours (9:00am-5:00pm) and inadequate awareness about the free services remain obstructive (54).

# Conclusions

This study demonstrates how a single free-roaming dog on rampage can cause multiple injuries, cascading economic losses and distress to peri urban communities. The high number of dog bites which occurred primarily in children and women was exacerbated by the urbanised and congested nature of the area coupled with the unprovoked and unpredictable aggression of the rabid dogs on rampage.

Loopholes in dog ownership, carcass disposal, consumption of livestock bitten by rabid dogs exposed glaring surveillance and public health gaps between the community and stakeholders responsible for public health in those communities. The lack of knowledge contributed to poor compliance to the WHO guidelines on preclinical management of the dog bite wounds while extortion, poor service delivery at public medical facilities discouraged the victims from accessing the rabies PEP. In summary, the study underscores the importance of a multifaceted approach involving community education, improving health care infrastructure, and addressing socio-economic factors to dissolve the tensions between humans and free-roaming dogs amidst fears of rabies. Until the factors identified in this study are addressed, it will be difficult to lower the incidents of dog bites and to achieve the WHO target to end rabies by 2030. Altogether, the case-based approach proved to be a reliable tool for active surveillance of dog bites and its utility is recommended for further case investigations in other areas in Uganda and beyond.

# Abbreviations

FAT: Fluorescent Antibody Test

NADDEC: National Animal Disease Diagnostics and Epidemiology Centre

PEP: Post Exposure Prophylaxis

WHO: World Health Organisation

WOAH: World Organisation for Animal Health

# Declarations

### Ethics approval and consent to participate

This study was approved by the Makerere University School of Veterinary and Animal Resources Research and Ethics Committee under registration SVAR/139/2023. Informed consent was obtained from all participants. For minors, the parents provided informed consent on behalf of their children.

### Consent for publication

Not applicable

### Availability of data and materials

The data that support the findings of this study are not publicly available because of restrictions under the licence for this study. Data are however available from James Okwee-Acai (james.acai@mak.ac.ug) or Dickson Stuart Tayebwa (dickson.tayebwa@mak.ac.ug) upon reasonable request and with permission of the School of Veterinary Medicine and Animal Resources Research and Ethics Committee.

### Competing interests

The authors declare that they have no competing interests.

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### Authors contributions

DST, RT, SB, JOA, DM and JK designed the study. DST**,** NKR, CS, AK, JM assisted with sample collection, administering interviews, and tracking the rabid dogs. DST, EW, and SAA performed brain extraction, histopathology, and fluorescent antibody test for rabies diagnosis. DST, MK, CS drafted the manuscript. JK, DM, RT, SB, JOA improved the manuscript draft. All the authors read and approved the submitted version of the manuscript.

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### Foot notes

[a]Classification of category of exposure to rabies from a dog bite. Category I involves contact between saliva and intact skin, Category II involves minor scratches on the skin without bleeding, and Category III involves bites accompanied by bleeding

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# Figures

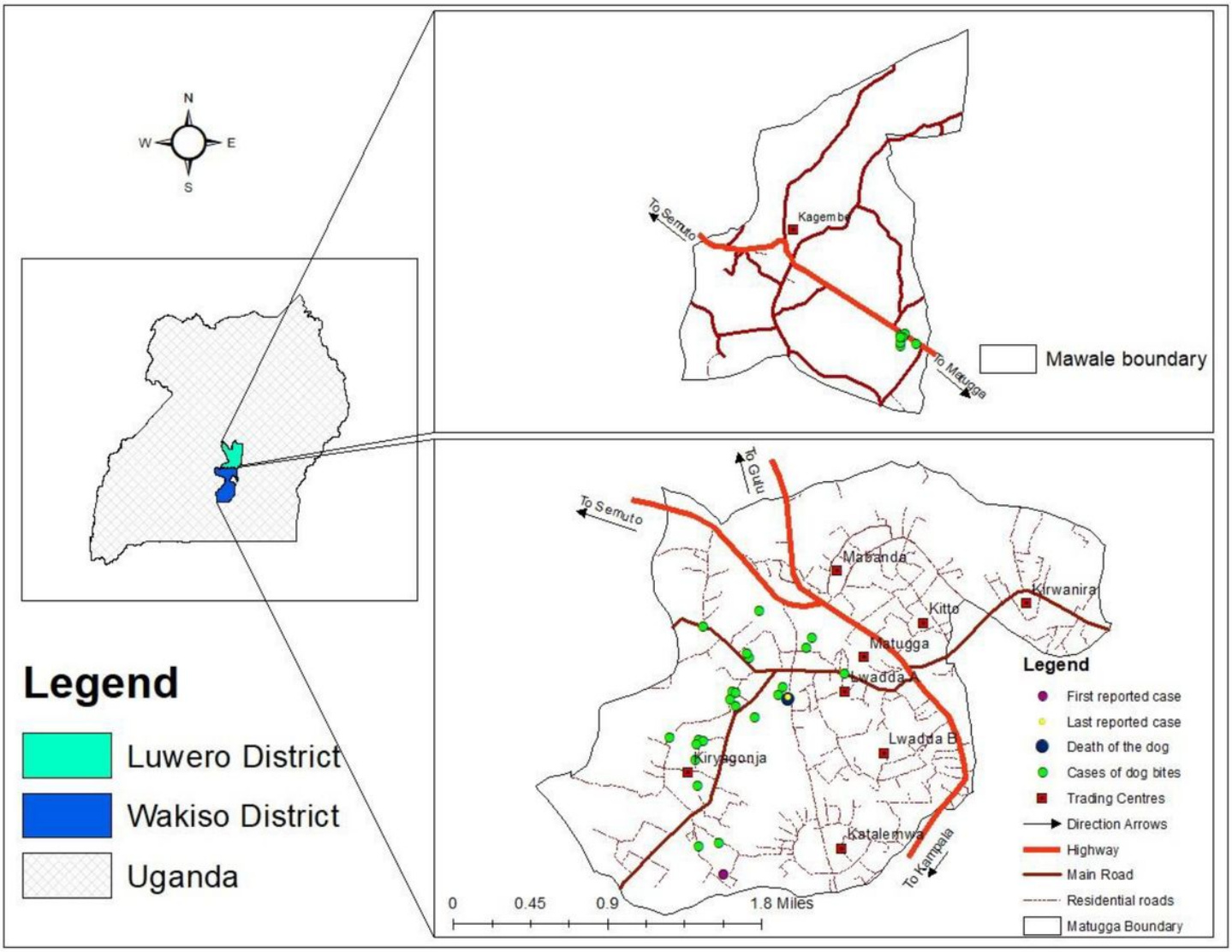
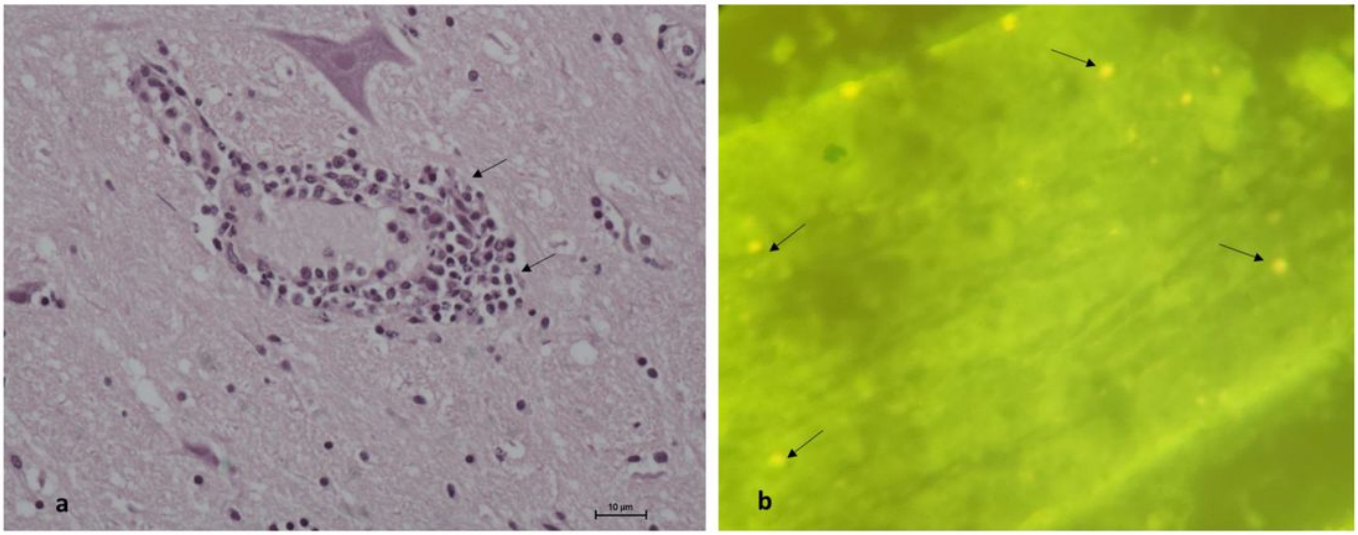



**Figure 1**

The location of the dog bites in Matugga and Mawale parishes

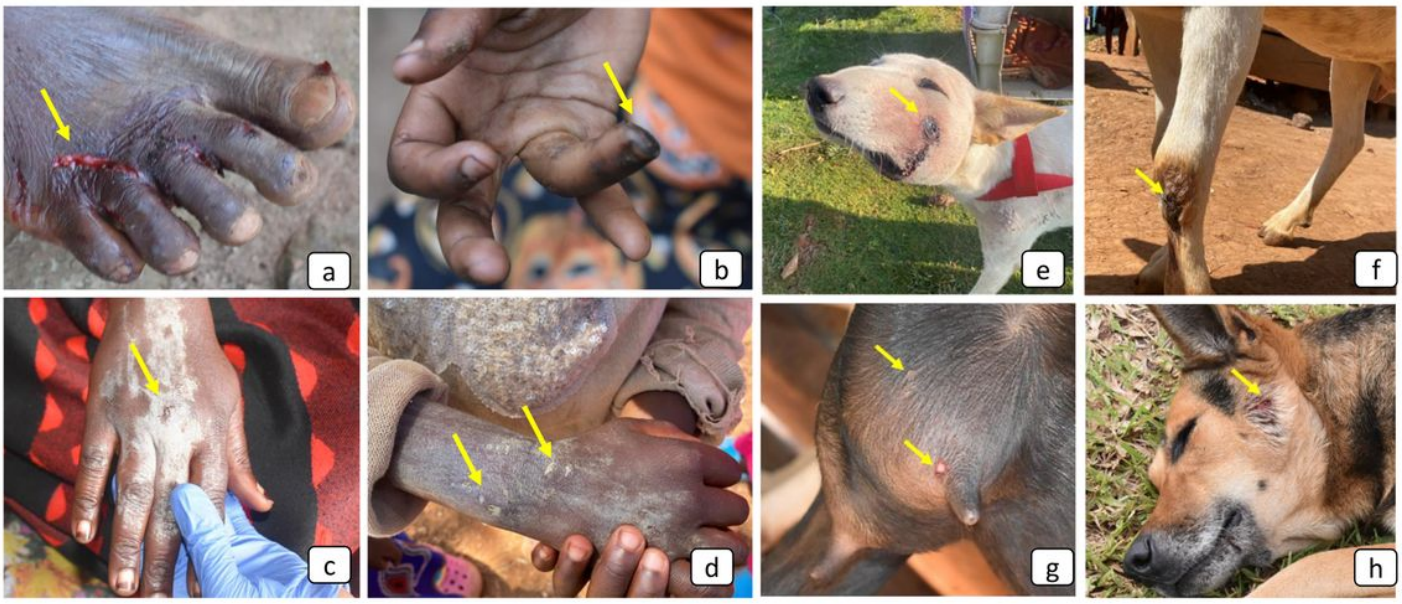
The green circles show the location where the dog bites occurred, the points for the first and last reported cases are marked by the red and yellow circle, respectively. The locations of the dog bites in Matugga are scattered while that in Mawale are clustered.




## Figure 2

Micrographs of histopathology and fluorescent antibody test for rabies diagnosis

The micrograph taken from the histopathology of the brain stem revealedmoderate to marked foci of perivascular cuffing by mononuclear inflammatory cells (image a), suggesting virus-induced encephalitis. Apple green florescent granules in the brain sample confirmed the presence of rabies virus antigen.




## Figure 3

Images of bite wounds inflicted on humans and domestic animals

The arrows show tears through the skin sustained by the dog bite victims (images a-d) and domestic animals (imaged e-h). Local herbs that were applied to the wounds of some dog bite victims appears as whitish substance smeared on the hands (image c & d).

## Supplementary Files

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